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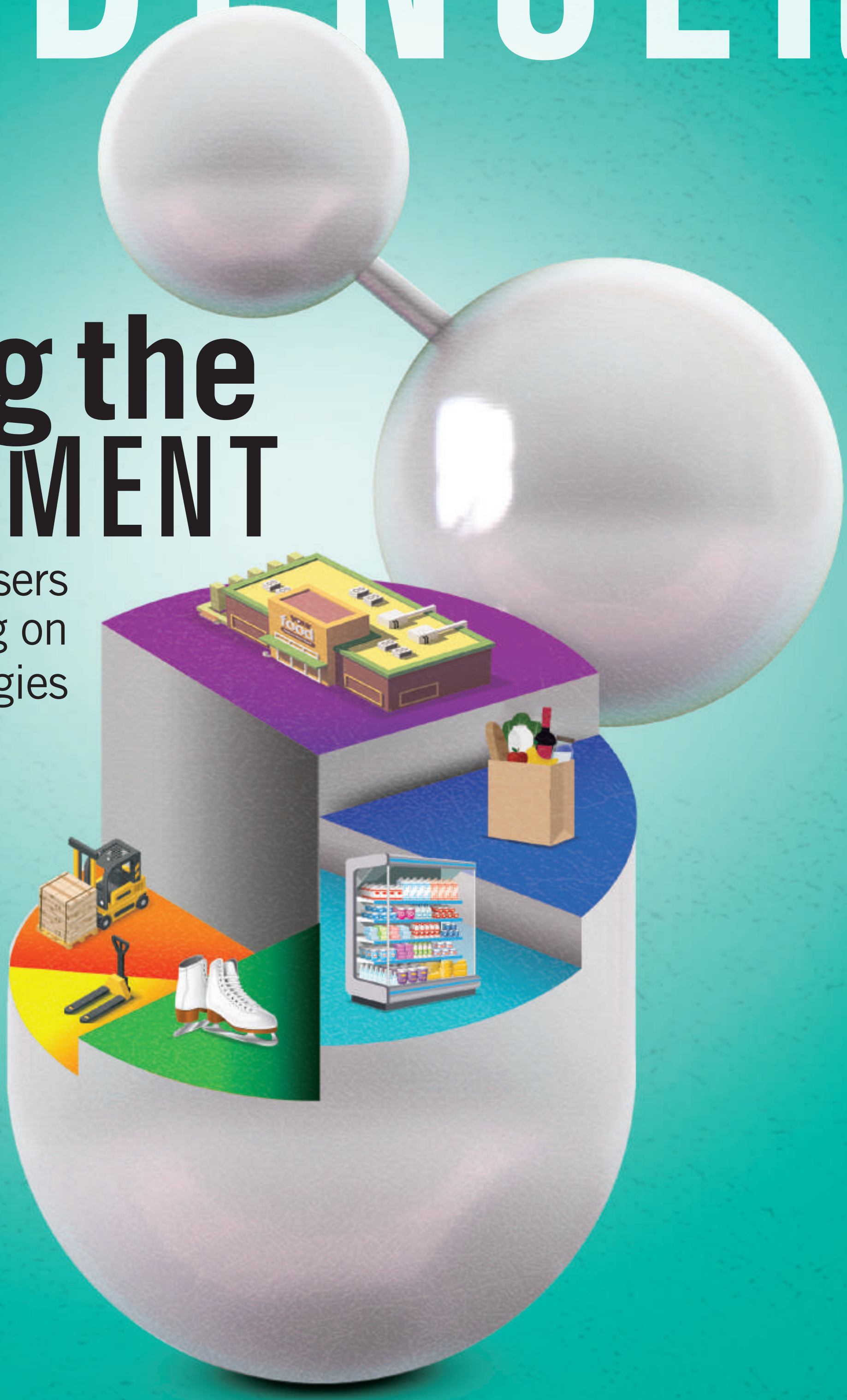
CONDENSER



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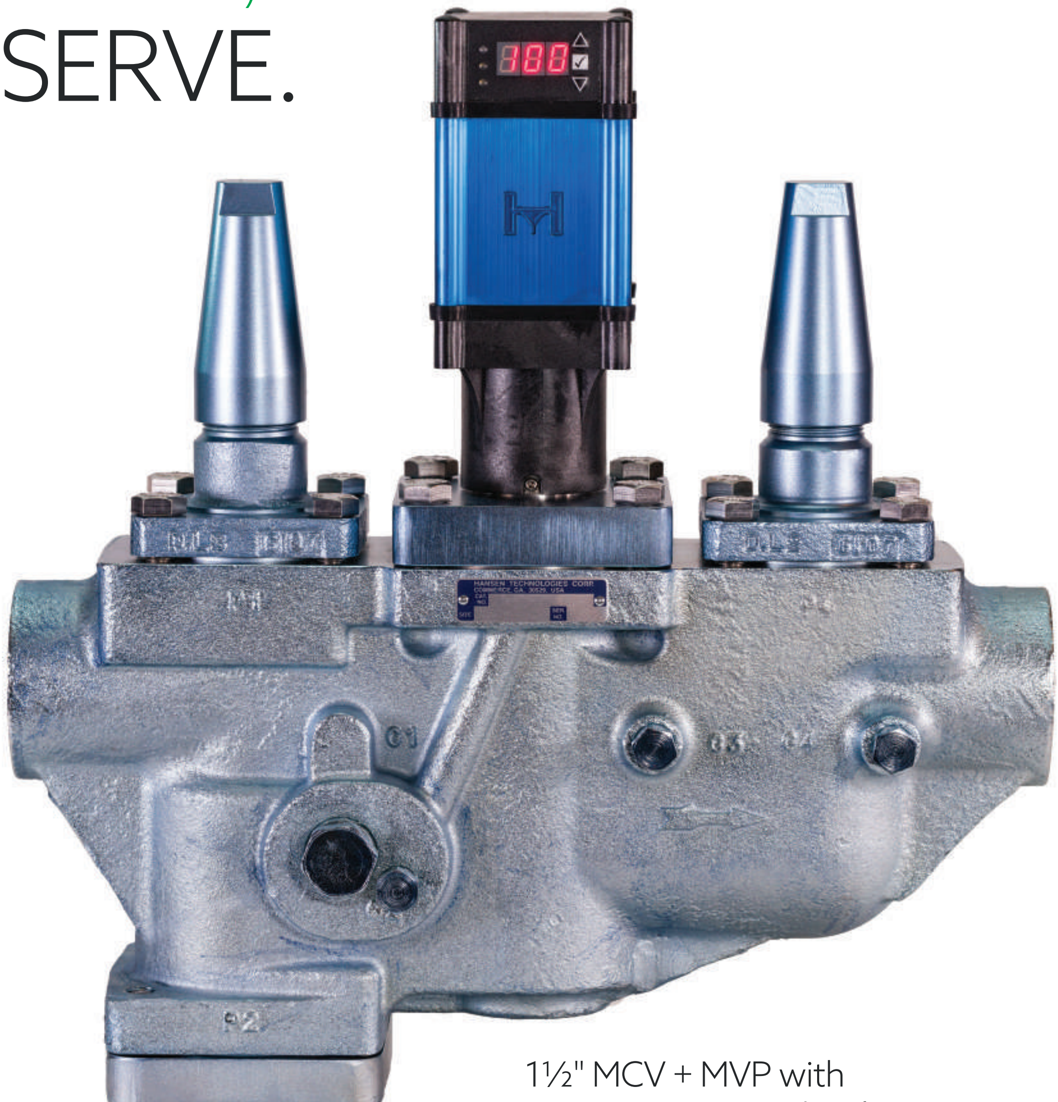

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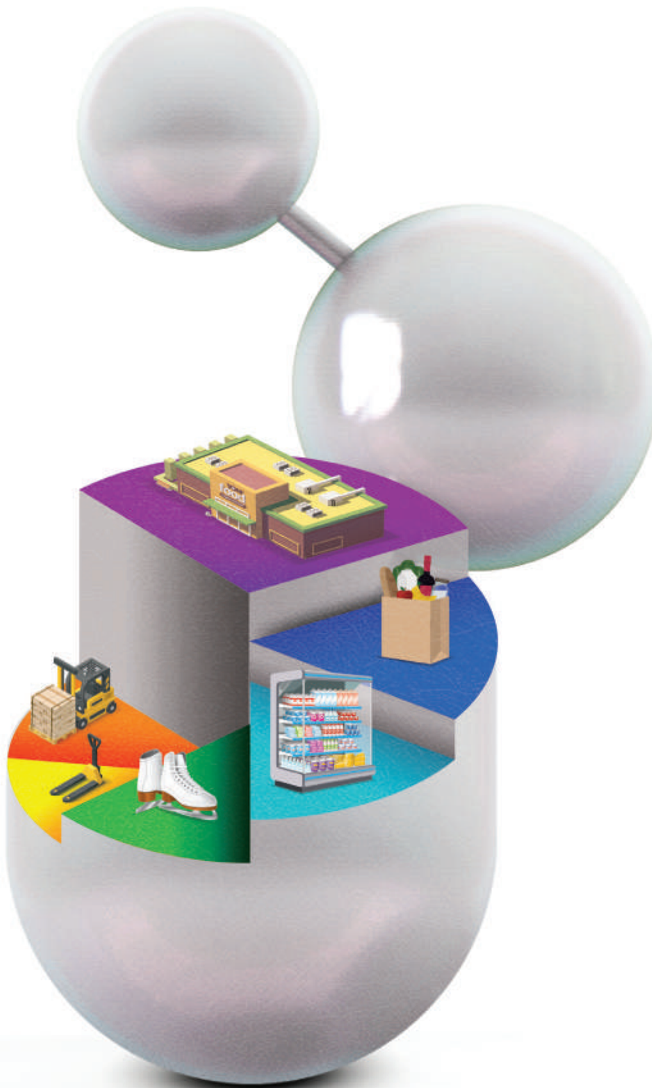

president's MESSAGE

BY DAVE RULE

In this issue of the Condenser, we're looking at the exit strategies that end users and manufacturers alike are using – to move away from hydrofluorocarbons and hydrochlorofluorocarbons. As former IIAR chairman Bob Port mentions in our cover story "There is a lot of internal pressure to get out of [HFC's and HCFC's] from a sustainability standpoint, but it has to come at a reasonable cost and be a good business decision."

Increasingly, moving towards natural refrigerants as a solution is both affordable and – considering advances in technology and corporate environmental responsibility – a good business decision.

For years, those of us close to this industry have seen the potential of natural refrigerants, ammonia, CO_2 and other refrigerants, to close the gap on the problem of global warming and ozone depletion. Now, that potential, and the opportunity that comes with it, is beginning to grow.

We're seeing a real investment in our industry's technology.

Package and low charge systems are growing like never before, and new applications for natural refrigerants are cropping up everywhere. That energy and focus has opened the door to new relationships, in places like the commercial refrigeration world and in the regulatory community, where we've forged important new relationships and found advocates for natural refrigerants.

As those new relationships – and new demand for natural refrigerants in traditional and non-traditional sectors – grow, our committees and volunteers are facing the challenge of meeting the needs of this major transition.

As an organization, IIAR will need double the manpower, engagement and enthusiasm of its members to help our industry grow and realize the potential that a move away from HFC's and HCFC's represent.

Fortunately, we're up to the task. Growing as an industry will mean developing and embracing the systems, components and innovation that will enable our core technology to find use in new environments and applications.

One example of this is automation. To keep pace with changing customer needs, and also deal with a severe technician shortage, facility owners are now making investments in the new ammonia system controls and sensors that are helping us automate safety, maintenance and efficiency.

While such an embrace of new systems can make our industry as a whole safer – when automation is used correctly and applied well – it can also add tremendous cost and create safety problems – when it isn't.

The challenge to IIAR, its committees, and members as a whole is to address new issues around automation and make sure appropriate standards are written that will help us apply new control systems in the best possible manner.

In this new environment, regulators will apply a broad brush when reviewing sensors and controls that are part of a system, placing their confidence on the side of automation. As a group, we'll need to be there to help guide where automation makes sense, and where our technicians and engineers should apply their expertise.

The challenge is for us to create the proper standards and guidance around sensors and control systems, and actively take control of how automation will shape our industry.

Right now, there is no definitive standard for automation, and the field of potential applications is so broad, it will be a task just to pinpoint where, and how, standardization should apply.

Nevertheless, this effort, as always with standards creation, will be an exciting way to engage the commercial, manufacturing and end user communities to ask them to participate in helping to shape our future.

We're in the process now of doing preliminary analysis of where, and how future standards around automation should apply

As an industry, our passion and dedication for what we do easily translates into the kind of "can do" attitude that is necessary to turn out much of the work we depend on to keep our core business future proof.

I'll end this month's column with a challenge to IIAR members and nonmembers alike. This year, become your industry's best advocate by taking an active role in the work of your IIAR organization. Get involved in the work of the IIAR committees and lend your voice and experience to our industry.

We're getting an excellent response and return on the work that we all collectively do on behalf of our industry, and that return just illustrates why your IIAR membership is so important.

We've just opened the 2017 IIAR membership renewal cycle and we're already getting an excellent response. If you haven't already, I encourage you to renew your membership so that you can continue to provide your input, participation and enthusiasm to this essential group for another year and beyond.

With your help and hard work, IIAR and our industry is poised for unprecedented growth.

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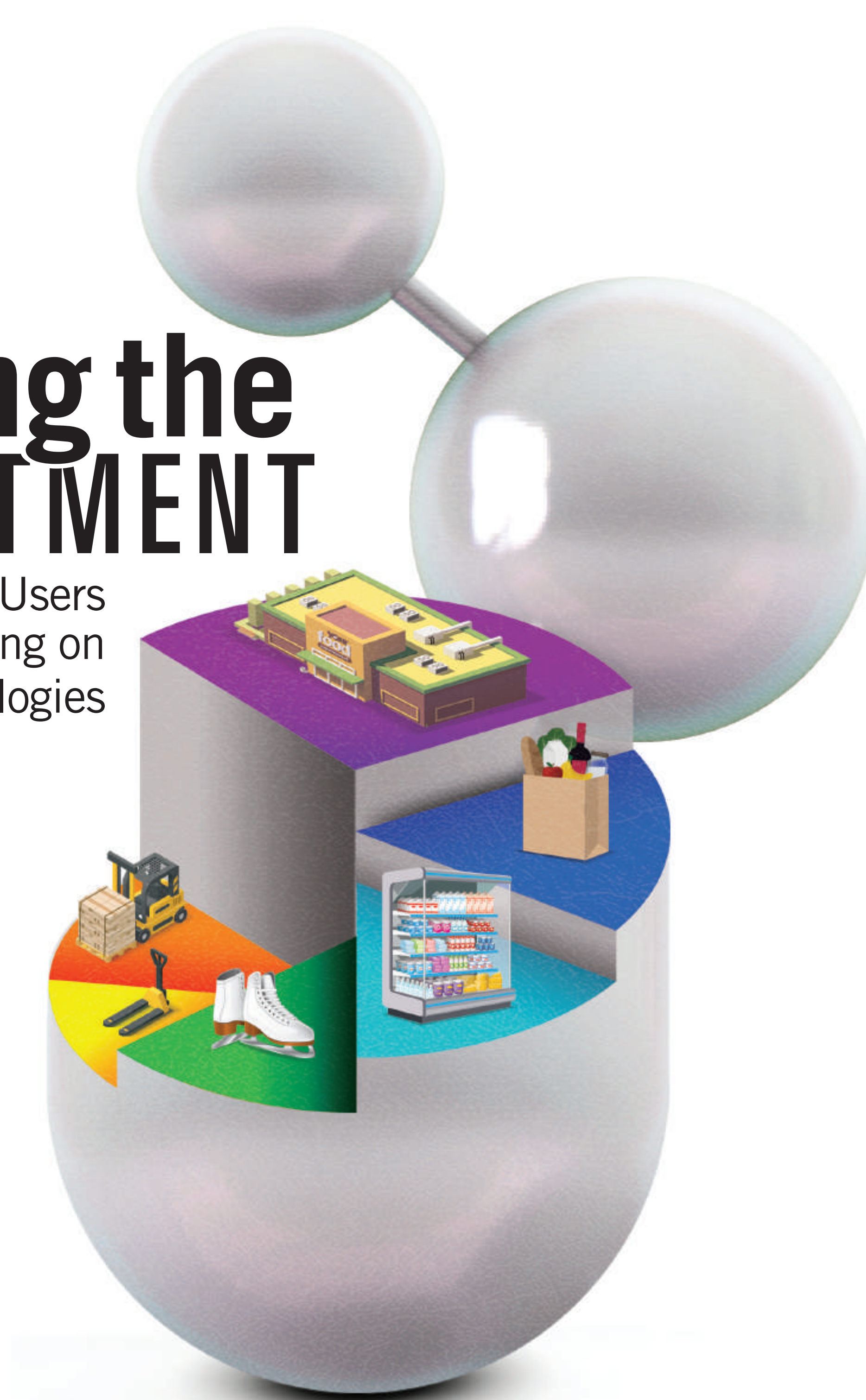

As they move away from refrigerants with high global warming potential, commercial and industrial refrigeration users said they're investing in new, natural refrigerant technology, including packaged ammonia systems and CO_2 transcritical systems. The move to newer technologies is allowing them to ease some regulatory burdens, increase efficiency and improve safety.

For example, ConAgra is forming exit strategies to move away from hydrofluorocarbons and hydrochlorofluorocarbons, said Bob Port, senior principle engineer, technical services, supply chain engineering. "There is a lot of internal pressure to get out of them from a sustainability standpoint, but it has to come at a reasonable cost and be a good business decision," he said.

ConAgra has installed a packaged ammonia system, but hasn't taken it live. "As we go further and further into trying to start it up we realize that the existing chilled water distribution system had never been engineered. It had just evolved over time," Port said, adding that he hopes the package system will go live soon and provide guidance for other plants that have commercial HFC refrigerants.

Port said he looks extensively at CO_2 every time a low, low-temp application comes along but hasn't been able to make it work. "It seems like every time we get a good application. The schedules are too tight. We have no room for error. It has to go like clockwork," Port said, adding that his team of contractors, engineers and plant employees are familiar with ammonia. "The CO_2 would be new. Our installation schedules are risky enough as it is, and, everything being equal, we're going to go with what we know and what we think is going to give us the best chance of success."

For Port, CO_2 could increase safety and reduce the risk of ruined product if a leak occurs. When ammonia leaks at -40 or below, it is a liquid leak, which is much harder and more dangerous to deal with. "Product losses are high, as packaging materials get saturated," he said, adding that ammonia detectors are not effective at detecting liquid leaks. "Liquid ammonia is a dangerous animal."

Bing Cheng, manager of utilities engineering at Campbell Soup Co., said their Pepperidge Farm bakery in Lakeland, Florida, has installed a CO_2 cascade system that will be commissioned in September. "This system will serve a small -10F storage freezer. It made sense to go with CO_2 since this refrigeration load is so small and the freezer is the only low-temperature load in this facility," he said.

In addition, Campbell's is installing a CO_2 cascade system for a new garlic-toast spiral freezer at a Pepperidge Farm bakery in Downingtown, Pennsylvania. It should be completed by the end of the year. "A lot of the CO_2 system applications have been used in storage coolers and freezers where the load is constant, but in this application, the load fluctuates as warm product is loaded into the spiral freezer," Cheng said.

Campbell's has installed a CO_2 transcritical system at its corporate headquarters in Camden, New Jersey, which should be in use by October. "Current regulations in New Jersey make it very difficult to install an ammonia system. It made sense to install CO_2 instead and avoid using ammonia and HFCs," Cheng said. The CO_2 system will support a new centralized storage cooler and freezer facility in the corporate research and development pilot plant.

The major catalyst for Campbell's changes was to reduce the use of ozone-depleting refrigerants. "Our company has made a commitment to reduce the use of HFCs at our facilities. That started with our R22 phase-out program to convert to low-charge ammonia and CO_2 packages," Cheng said, adding that adopting natural refrigerants is a good long-term strategy for the company, from an economic and sustainability perspective.

Bob Czarnecki, chairman of the International Institute of Ammonia Refrigeration standards committee and a retired refrigeration program manager at Campbell Soup Co., said CO_2 is becoming more and more usable in the commercial sector, particularly in storage freezers. "You have a lot of applications where you're trying to get away from HFCs. It is easily done with ammonia in most cases but you may have one really small freezer and to put in all kinds of equipment for one freezer doesn't make sense," he said.

One of the challenges of CO_2 transcritical systems has been a potential lack of efficiency in warm climates. Different control strategies, as well as ejector technology, parallel compression, adiabatic gas cooling condensing and external subcooling, have changed that.

John Gallaher, vice president of industrial refrigeration for Hillphoenix Inc., said the commercial sector is also seeing some adoption of CO_2 transcritical systems. Tristam Coffin, director of sustainability and facilities at Whole Foods Market, said CO_2 transcritical systems are the lion's share of the natural systems used in commercial applications today.

In its store in Santa Clara, California, Whole Foods installed seven modular units with R290 charges in a CO_2 cascade system. "There are a variety of different systems and architectures out there but CO_2 plays a role in all of them, but there is a huge area of opportunity with the introduction or market adoption of technology," Coffin said.

One of the challenges of CO_2 transcritical systems has been a potential lack of efficiency in warm climates. Different control strategies, as well as ejector technology, parallel compression, adiabatic gas cooling condensing and external subcooling, have changed that, "We're driving efficiency up and using less energy, which is valuable," Coffin said.

Mark Menzer, director of public affairs for Danfoss, said he is seeing increased consideration of parallel compression CO_2 systems with ejectors, which have made CO_2 refrigeration systems more economical, especially in warmer climates. "Before this you could almost draw a line around the northern latitudes of the world and say CO_2 systems are economical above this line, but not below. That has changed with this ejector technology," he said.

Some companies are investing in new technology to improve energy efficiency, said Andre Patenaude, director of CO_2 business development for Emerson Climate Technologies. Energy costs can vary by region, which in turn can drive the return on investment. "In Europe, they've been trying to push the envelope on energy and refrigerant regulations before North America," he said.

Patenaude said customers are looking to reduce megawatts. "CO_2 can do continuous heating and cooling, so your efficiencies are through the roof. What is slowing us down is large compression technology for CO_2, which we have, but it hasn't been used in a building quite yet," he said. He explained that it is still being done, but with multiple compressors; however, industrial users don't like 12-15 compressors.

CO_2 transcritical systems are becoming almost prevalent enough to be called mainstream, said Keilly Witman, owner of KW Refrigerant Management Strategy.

Caleb Nelson, vice president of business development at Azane Inc., said low-charge ammonia, as well as propane systems, have been used commercially in cascade CO_2 systems for supermarkets, but CO_2 transcritical has seen the largest number of installations where a 100% natural system is adopted.

The concept of micro-distributed propane systems is gaining some traction. "With the potential to have allowable propane quantities increased in the U.S., propane will become a much larger competitor of CO_2 for commercial systems," Nelson said.

Witman said propane and CO_2 systems are an intriguing idea because of propane's energy efficiency. "It can work in any climate very, very easily," she explained.

Danielle Wright, executive director of


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the North American Sustainable Refrigeration Council, said, "There is a lot of buzz about the fact that you could build a store with all standalone self-contained cases that run on propane and eliminate the need for a remote system all together. We are seeing this as a trend in Europe in small format stores."

Coffin said technology has evolved more in the last decade than it had in the last 100 years. "The overall management of systems is becoming much more automated," he said.

The "Internet of Things" is providing greater connectivity, and the cost of IOT devices is coming down, so manufacturers can add devices to equipment and provide remote monitoring. "Those are driving innovation regardless of the size of equipment, whether you're talking about industrial or commercial," Patenaude said.

Patenaude said some facilities are upgrading electronics so they can remotely monitor their stores. "The refrigeration may have a 20-year life span, but if they need better tracking or reporting, you can add more sensors and temperature controls and improve performance and monitor equipment," he said.

There is a lot of buzz about the fact that you could build a store with all standalone self-contained cases that run on propane and eliminate the need for a remote system all together. We are seeing this as a trend in Europe in small format stores.

–Danielle Wright, executive director of the North American Sustainable Refrigeration Council

MAKING THE RIGHT DECISIONS

Companies generally make a change in technology when they replace equipment or they take an interim step and add new technology to existing equipment, but end users have many different variables they need to go through when determining which systems to invest in because the pace of technology is changing very quickly, Patenaude said. "They don't want to be guinea pigs on new technology and have maintenance costs go through the roof," he said.

Technology changes in the industrial refrigeration space are often driven by regulatory demands, Hillphoenix's Gallaher said. "People are looking at how they can get out from the regulatory burden. Other customers are looking at how they can get out of ammonia completely because there are certain areas that are going to even more restrictions on ammonia," he said.

EPA's SNAP program, section 608 of the Clean Air Act, and the Montreal Protocol have all refocused attention to HFC restrictions. "HFC phase-out and carbon reduction is the direction most, if not all, of the developed world is headed," Nelson said.

Menzer said a federal court recently ruled that the U.S. Environmental Protection Agency's SNAP Program exceeded its authority under the Clean Air Act with its 2015 rule that eliminated some uses for hydrofluorocarbons. "There is a tremendous amount of confusion right now," he said. "EPA only has the authority to regulate the ozone-depleting substances and once they are out you can't regulate them anymore."

Even if there isn't a SNAP program, there are other regulations. For example, California is poised to leap-frog the European Union's phase out of fluorinated greenhouse gases, which include HFCs, regardless of what the U.S. federal government does, Nelson said. "So those doing business in California, or those that want consistency across the US or international markets, will invest today in technology that they believe will be viable for the long haul," he explained.

Plus, the European Union's HFC phase-out schedule is more aggressive than the U.S. equivalent, Menzer explained.

"A lot of the new R&D and product development is focused on natural refrigerant technologies, which is an indicator that this is the direction we're all heading," Wright said.

Nelson said he is seeing technology investments happen independently of regulatory pressure. "Even if there is a lack of U.S. federal pressure on HFCs today, many realize that it's just around the corner," he said.

Some end-users are entrepreneurial and want to be ahead of the curve. "They'll spend more money on [capital expenditures] to learn something new before their competitors," Patenaude said.

Companies that see themselves on the leading edge want to show sustainability to their shareholders and customers. "Another group will do lifecycle costs and look at the future and being future-proof," Menzer said.

Companies may invest in natural refrigerants without SNAP due to the economics, but regulations can help. "There are some borderline cases where conservative users won't use the new technology unless they have a regulatory push as well," Menzer said.

Nelson said end-users have to look at life-cycle costs when considering new technology. Although newer technology will typically come with a higher capital cost until it gains economies of scale, there are opportunities to improve running costs, reduce safety risk, lessen regulation, increase reliability, and use stable, low-priced refrigerants, he explained.

Deciding when to make a change can depend on existing system's age, condition, leak rate and maintenance costs. "One of the biggest opportunities is to take advantage of system replacements and new construction to install a future-proof system to avoid future retrofits or spiking refrigerant costs like Europe is seeing," Nelson said.

The importance of new technology can depend on the industry. Patenaude said technology is advancing more rapidly in the food space because of the Food Safety Modernization Act, which requires additional record keeping and reporting. "Just writing temperatures on a clip board twice a day isn't cutting it, so they need to automate the process, the IOT technology is doing it for them," he said.

UNDERSTANDING THE BENEFITS AND CHALLENGES OF NATURAL REFRIGERANTS

CO_2 cascade systems, which can use ammonia or propane as a refrigerant in small quantities, are providing efficiency and fewer safety concerns and can reduce reporting requirements. "As you get out of the record keeping required with high global-warming-potential refrigerants, there is a lot less hassle," Menzer said.

CO_2 is also gaining traction industrially to improve the safety of what would otherwise be a large-charge ammonia system. "By using ammonia to only cool or condense CO_2, which is then sent throughout the facility, ammonia charges can be reduced and also limited to the machinery room," Nelson said. "Ammonia-CO_2 cascade systems can also improve on the efficiency of full ammonia systems where extremely cold temperatures are required (i.e. -40F)."

Temperature sensors, humidity controls and other sensors are working together to optimize performance, Patenaude said. Emerson provides technology that can track temperatures from the field and to the store. "That technology is becoming very important to end users," he said. "I'd like to have some temperature guarantees that have some shelf life."

The overarching challenge for some advanced technologies relates to the lack of codes and standards for their use in the field. "Developing new codes and standards or revising old ones is a long process and it is going to take the work of the entire industry," Wright said.

Technician Shortage Will Accelerate New Technologies

New refrigeration technologies are making maintenance easier, which is increasingly important as the industry faces a technician shortage, end-users and equipment providers said.

"We have fewer and fewer technicians in the field. The shortage is going to get worse and worse as time goes on," said Keilly Witman, owner of KW Refrigerant Management Strategy. "Recognizing that, we have to ask ourselves as an industry if we should be betting on refrigeration technology that increases complexity or should we prioritize simplicity? What good are complex, high maintenance systems if there is no one to maintain them?"

Tristam Coffin, director of sustainability and facilities at Whole Foods Market, said he'd like to see the refrigeration industry get to a level similar to what the automotive industry has achieved.

"If you go to an automobile dealership today, they're going to plug the vehicle into a computer and get the diagnostics. I think the industry is moving in that direction where everything will be better automated and better controlled and you could go to a grocery store, plug in, run the diagnostics on the system and make repairs and replacements," he said.

That vision isn't too far out of the realm of possibility. New technologies like package and low charge systems, as well as improvements in valve design, control, remote monitoring and more sophisticated computer software – are playing at least a small role in helping companies work more effectively despite a technician and operator shortage.

Andre Patenaude, director of CO_2 business development for Emerson Climate Technologies, said reducing the complexity of systems is a priority. "Contractors are concerned with providing good quality technical support. They turn to companies like Emerson and ask us to make equipment easier for techs showing up at the job site," Patenaude said.

What's more, because there is a lack of qualified technicians, contractors aren't always able to dedicate time to training on new technology. "There is a 'Catch 22' for contractors. They want the training, but there aren't enough systems that use that technology out there to warrant the investment in time and money that wholesale training requires," said Danielle Wright, executive director of the North American Sustainable Refrigeration Council, an environmental non-profit that focuses on natural refrigerants.

One solution is self-contained units, which require less maintenance, Wright said.

To help improve training, Danfoss has developed a training module within a shipping container that serves as an instructional base for using CO_2 systems and learning how to deal with high pressure CO_2, said Mark Menzer, director of public affairs for the company.

"We've spent a lot of time training the installation crews and the contractors," said John Gallaher, vice president of industrial refrigeration for Hillphoenix Inc.

Campbell's Soup Co. has installed three new CO_2 systems this year. "CO_2 is a brand-new technology for our company, and there is going to be a learning curve for our personnel," said Bing Cheng, manager of utilities engineering at Campbell Soup Co. "Once we described how easy it is to operate, they were more receptive to CO_2. Our people do a great job operating and maintaining our current ammonia systems, which is much more complicated than some of the new CO_2 systems."

Did Amazon Just Invest in Natural Refrigerants?

In August, Amazon completed its $13.7 billion purchase of Whole Foods Market Inc., and the e-commerce giant now owns the upscale grocer Whole Foods, which is based in Austin, Texas, and has more than 460 stores in the United States, Canada and the United Kingdom.

Amazon currently operates fewer than 100 distribution centers in the U.S., so the Whole Foods acquisition will expand the online retailer's logistics network.

Since Whole Foods has taken the lead on natural refrigerants and has been one of the more progressive chains in piloting advanced systems using natural refrigerants, wide-scale adoption of natural refrigerants by Amazon could help drive greater adoption within the grocery industry.

"Let's face it: no one knows at this point what Amazon's intentions are with respect to the future of refrigeration at Whole Foods Market, and both Amazon and Whole Foods have been completely mum on the subject. If I had to guess, I'd say that Amazon might be open to investing in more natural refrigerant technology, because that's an investment that makes sense if you've got a long-term perspective," said Keilly Witman, owner of KW Refrigerant Management Strategy.

"One thing we know about Amazon is that they focus more on a long-term vision than I feel the supermarket industry is used to doing. Think of all of those years when Amazon first got started and they lost money year after year. The company accepted those losses because they knew their long-term vision was solid," Witman said.

"Also, as part of the tech industry, Amazon is likely more comfortable with the idea of paying high upfront costs to bring newer technologies to the mainstream, Witman explained. "That has to bode well for natural refrigerants. A heavy Amazon investment in naturals could be enormously influential in achieving economies of scale and bringing prices down across the whole industry."

> **"A heavy Amazon investment in naturals could be enormously influential in achieving economies of scale and bringing prices down across the whole industry."**
>
> **–Danielle Wright, executive director of the North American Sustainable Refrigeration Council**

Danielle Wright, executive director of the North American Sustainable Refrigeration Council, said the natural refrigerants industry is trying to figure out how to build economies of scale faster. "If you talk to any grocer, they know we'll eventually achieve those economies, but in the meantime, nobody wants to be on the bleeding edge. They're all waiting for prices to come down, and prices won't come down until manufacturers achieve economies of scale. It's a big catch-22," she said.

For grocers, investing in natural refrigerants could ease companies' regulatory burden, as these refrigerants are exempt from the EPA's Section 608 regulations. Section 608 of the federal Clean Air Act, which outlines refrigerant management regulations. "If you eliminate that record keeping burden, that is one less thing for you to worry about," Wright said, adding that natural refrigerants are future-proof.

However, Witman said she doesn't think Whole Foods' use of natural refrigerants factored into Amazon's decision to acquire the grocer. "In mergers and acquisitions that involve supermarket companies, it's unusual for refrigeration to be discussed as part of the deal," she said.

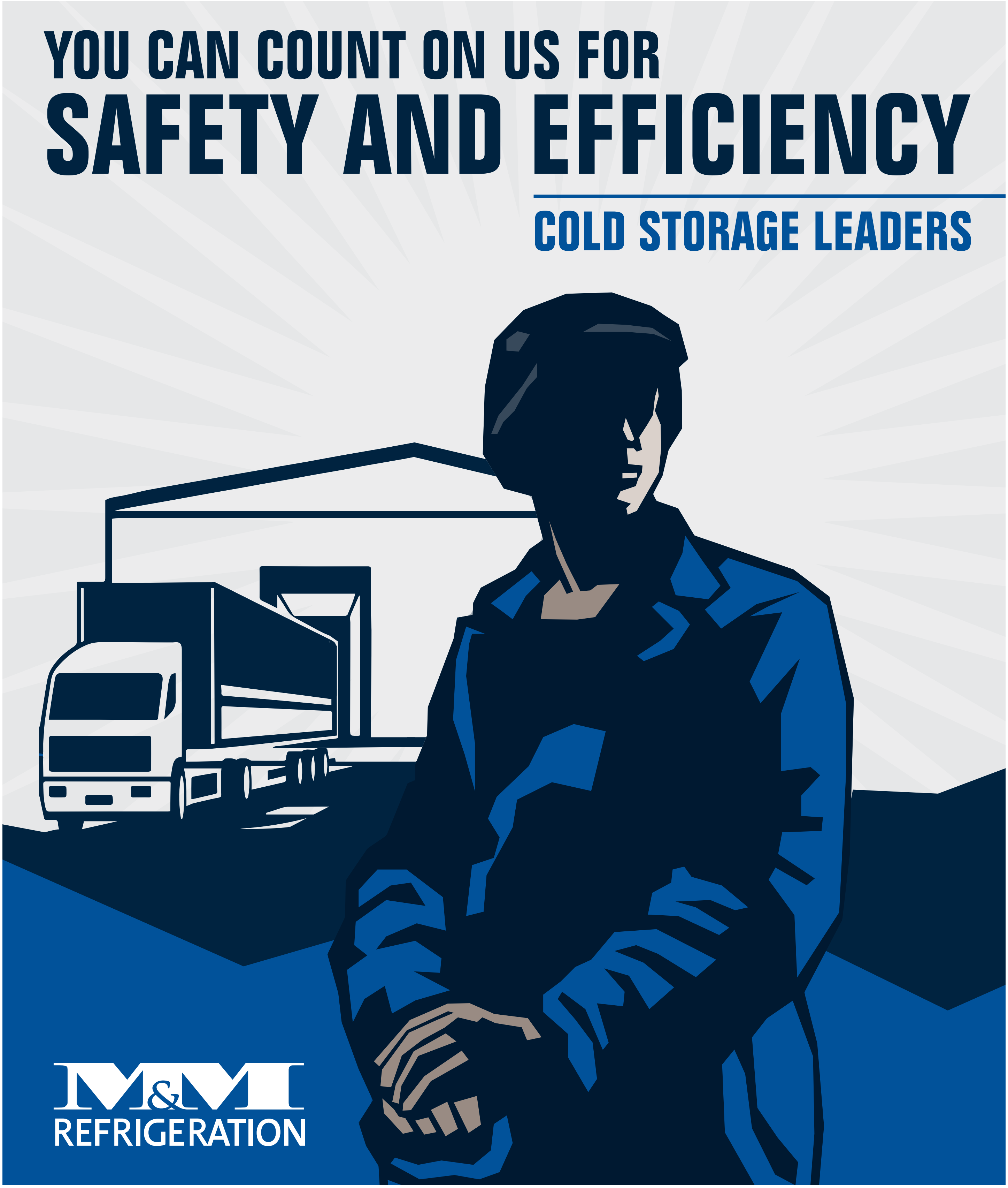
Wright said natural refrigerants are not yet the standard choice for grocers, but they are further along than they were just two years ago. "There were just a few systems years ago and now there are hundreds. That is a lot when you figure it takes a long time for new technologies to be adopted in an industry run on tradition," she said.

One challenge for grocers is there isn't an easy option for retrofitting old systems with natural refrigerants, so the technologies typically are considered only during new store construction, Wright said.

Wright added she would also like to see utilities provide incentives for natural refrigerants, which would spur investment.

Witman said traditional grocers don't jump on board with trends quickly, but Amazon may be different. "Amazon was created by people who imagined a future that was completely different from the way things were, a future that most people thought was completely nuts at the time," she said.

Whole Foods declined to comment for this story and Amazon did not return a request for comment.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Comparing Ammonia to 1234yf

Although ammonia has been the refrigerant of choice in industrial refrigeration systems for more than a century, it has faced competition from numerous synthetic refrigerants, most recently 1234yf and R32. Although the use of ammonia brings with it a greater regulatory burden, it remains the more logical choice of refrigerant in larger refrigeration systems, especially from a safety, efficiency and environmental standpoint.

From a safety perspective, ammonia possesses numerous advantages over 1234yf. For example, while both refrigerants have reasonably comparable heat of combustion and flame-spread characteristics, ammonia has a much higher required vapor density at standard air temperature and a higher auto-ignition temperature, critically important features in the case of a release. Exhausting ammonia, especially from an equipment room, is relatively easy and does not present a global warming issue.

"Ammonia has a low molecular weight, and its vapor is inherently light," says Jerry von Dohlen, president of Newark Refrigerated Warehouse. "So, if ammonia leaks in an engine room, the vapor will rise to the ceiling. That makes it easy to get rid of the vapor by placing fans on the ceiling. When you sense a leak, you increase the fan rate, the ammonia is shot into the air at a high velocity and it rises and dissipates."

Conversely, 1234yf vapor is almost seven times heavier than ammonia and in the event of a leak it will drop to the floor, displacing breathable oxygen. When 1234yf falls to the floor, people can suffocate before even realizing they are in danger and that means there is a great reliance on refrigerant detectors.

That leads to another advantage with ammonia, which is that it can be detected at less than five parts-per-million. People can tolerate ammonia at an exposure of up to 300 ppm for short periods of time without ill effects. And ammonia's odor provides a self-alarming system, causing people to evacuate the area, while 1234yf is odorless, making it a potentially silent killer.

"No matter how much ammonia is released it will not affect the ozone layer or the global warming potential," von Dohlen said. "It's a natural refrigerant, so there is zero impact on the environment."

Furthermore, the lower liquid density of ammonia allows for easier low-side oil separation. Oil adds to the flammability of any refrigerant. In the case of a fire, extinguishing the flame is easier with ammonia because an ammonia-air mixture with 10 percent or more water vapor will not support combustion.

Plus, if a fire occurs with 1234yf, it will emit poisonous gasses. "If you breath ammonia when it burns it may make you sick," von Dohlen said. "But if you breathe burned 1234yf, you could easily die."

Ammonia is also a better choice when it comes to efficiency. Ammonia's heat of vaporization is 589 BTU/lb., versus 77 BTU/lb. for 1234yf. Therefore, to achieve 589 BTU of cooling with ammonia you would pump one pound, as compared to almost eight pounds with 1234yf. "Any time you are pumping through a pipe you have frictional losses, but those losses are much lower with ammonia than with any other refrigerant at common temperatures," von Dohlen said.

There are other advantages to using ammonia. The compression of 1234yf is less efficient because it requires nearly twice as much compressor displacement. Ammonia's boiling point is lower, which means it will be in a vacuum less often for medium- to low-temperature applications. Ammonia is also less expensive, around 88 cents per pound, compared with a 1234yf and R32 price of $40 to $50 per pound. Ammonia is a common commodity and is available nearly world-wide.

Finally, ammonia is a wiser environmental alternative. "No matter how much ammonia is released it will not affect the ozone layer or the global warming potential," von Dohlen said. "It's a natural refrigerant, so there is zero impact on the environment."

The principal drawback to ammonia is the current regulatory burden. The EPA requires a facility to report within 15 minutes an ammonia leak of 100 pounds or more over the preceding 24 hours. "Ammonia weighs a little less than six pounds per gallon, so 100 pounds is equal to about five-gallons a can spilled on the roof over 24 hours," von Dohlen said. "There are people adopting 1234yf because they don't want to deal with the excessive regulatory burden of ammonia. But if the government would consider the physical properties of ammonia vs. other synthetics it would realize that ammonia offers many benefits to our food chain and, due to improved efficiencies, could significantly reduce refrigeration industry demands on our electrical grid.

"In the end, the benefits of ammonia are safety, efficiency, the cost and the fact that it's good for the environment. If the regulatory burden can be reduced, the choice of ammonia is a no-brainer," von Dohlen said.

iiar 2018 NATURAL REFRIGERATION CONFERENCE & EXPO

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- Air as a Refrigerant
- The Impact of Air Treatment on Food Safety
- Best Practices in Managing an OSHA NEP Inspection
- Employee Engagement as an Indicator of PSM Program Success or Failure
- Ammonia Defrost Systems
- Facts and Myths in Choosing Construction Materials for Evaporative Condensers
- Stainless Steel Piping in Ammonia Refrigeration Systems
- And More

Workshops:

- Updated Machinery Room Ventilation Calculation Tool
- Ammonia Scrubbing with CO_2
- Use of Water as a Refrigerant
- World Guide to Low Charge Ammonia
- And More

For a complete list of Presentations and Topics visit **www.iiar.org/Annual Conference**.

IIAR Sunday Education Program

Mechanical Integrity for Ammonia Refrigeration Systems

*Sunday March 18th, 2017 • 1:00 PM – 5:00 PM • 4 PDH/CEU

Join us at the 2018 IIAR Natural Refrigeration Conference & Expo for the Sunday afternoon IIAR Education program – Mechanical Integrity for Ammonia Refrigeration Systems. This Education program highlights the importance of mechanical integrity, how it relates to process safety management and the General Duty Clause. Topics include:

- The components of a mechanical integrity program
- Minimum requirements of inspection, testing and maintenance
- Mechanical integrity procedures for equipment, piping, vessels and safety systems
- When corrective action needs to be taken
- Preventative maintenance, audits, training, and quality assurance

From pumps to vessels, this program will provide a comprehensive outline of compliance with regard to Mechanical Integrity for Ammonia Refrigeration Systems.

additional fees apply

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Our upcoming 2018 IIAR Natural Refrigeration Conference & Expo will be held in Colorado Springs, Colorado at the beautiful Broadmoor Hotel and Resort. An IIAR Conference guest favorite, this venue provides ample meeting space and ambience to enhance your overall conference experience.

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YEAR IN REVIEW

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AND MUCH MORE!

HANK BONAR

"As we move forward with a new congressional administration, along with updated regulations to guide cold-storage, it is imperative to fund innovative research that makes our industry more effective and beneficial. That's why Bonar Engineering is invested in supporting the Ammonia Refrigeration Foundation. The Foundation offers valuable insight into the latest technology and trends, as well as immediate assistance with any issues or questions regarding anhydrous ammonia refrigeration. Great Folks! Great Foundation! Great Opportunities! **Let's make ammonia great again!**"

EDUCATION

NEW NAME: FOUNDERS SCHOLARSHIP

Following the passing this year of one of the original founders of the International Institute of Ammonia Refrigeration (IIAR), The Foundation Board of Directors decided to rename the existing ARF Scholarship in recognition. The **Founders Scholarship** will honor the legacy and significant contributions of George Briley, Chuck Hansen, Don Niederer and Bill Richards to the ammonia refrigeration industry as the primary founders of IIAR. The **Founders Scholarship** will be awarded each year to students exhibiting exceptional character and interest in pursuing an engineering or related technical degree leading to a career in the refrigeration field.

DON NIEDERER ⋮ One of the original IIAR founders

"Thank you so much for your efforts in making the Founder's scholarships and awards possible. George would be so pleased. He worked so hard creating IIAR."

–MRS. PHYLLIS BRILEY, WIDOW OF GEORGE BRILEY

ANDREW RE AND JACOB UPTON
2016 scholarship recipients with
Bob Port, Scholarship Sub-Committee Chair

2016 WINNERS

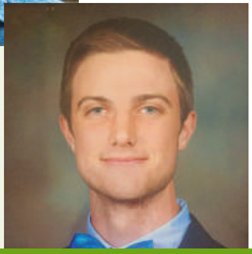
Additional thanks to PRAXAIR for their support of a PRAXAIR Diversity Grant for a student to attend the IIAR Conference. This year's recipient was **Ford Barnes, III (Trey)** who, like our other two scholarship recipients, had a wonderful experience.

This year, The Foundation increased the dollar amount given to scholarship recipients, as well the actual number of recipients. The Foundation also tripled the application pool by outreach with ASHRAE and the Veteran Student Association to make them aware of our programs and initiatives.

2017 WINNERS

JAMES SCHUBERT ⋮ Cal Poly

RACHAEL SEALOVER ⋮ University of South Carolina



CONNER WHEELER ⋮ University of Missouri

THE FUND FOR RETA CERTIFICATION/TRAINING

The Foundation and Refrigerating Engineers and Technicians Association (RETA) joined forces and created a fund to provide grants to military veterans, guards and reservists who wish to study in RETA certified training programs across the country.

Jim Barron, RETA Executive Director indicated his support for the partnership. "This is in keeping with RETA's mission statement of developing operating technicians and professional engineers," he said. "We have veterans coming out of the service that need a job or a skill, or who want to continue on with the things they have already learned. This is right up their alley. For us to be able to do something of this nature where we can train these veterans and keep our industry moving forward is a positive thing."

Donations can be designated specifically to this new fund. All money raised will be used for grants for transitioning military and/or guards and reservists to support the training at trade and technical schools that are using the RETA certification curriculum.

"This is part of our new mission to develop individual talent and to build a bridge between two organizations that might be distinct and different, but that also have similar goals and purpose," said Lois Stirewalt O'Connor, Executive Director of The Foundation.

"This is an exciting new venture. It is an opportunity as a Foundation to provide access for developing talent and to maximize the skill sets and opportunities for our men and women in the military."

LOIS STIREWALT O'CONNOR

RESEARCH

The Foundation funds quantitative and/or qualitative industry research projects to support and enhance the advancement and sustainability of the natural refrigeration industry. Research projects are proposed and evaluated on a variety of applications to include overall impact to the industry, significance and innovation.

In 2017, The Foundation approved two new research grants/projects for funding:

OBJECTIVE

Development of a Mechanical Insulation Installation Guideline for Refrigeration Applications. Potential bidder list is being developed and RFP's will be out by this publication.

OBJECTIVE

CFD Simulation of an Ammonia Dispersion with Refrigerated Spaces — to determine the required placement of ammonia sensors in a production room. The RFP's have been sent to qualified bidders and project quotations are being received at IIAR headquarters.

THANK YOU

Annual Giving

As a 501(c)(3) educational and research organization, The Foundation depends upon the tax-deductible financial support of individuals, corporations and foundations.

Donors who reach an annual cumulative donation level of $150 or more during the fiscal year are recognized through the year in a variety of ways for their commitment to the advancement of The Foundation and its mission.

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You can also make an investment to the Ammonia Refrigeration Foundation by giving a gift that would cost nothing during your lifetime. Join the **LEGACY SOCIETY** and help strengthen the mission and programs of The Foundation by providing future support through a planned gift. To learn more, visit nh3foundation.plannedgiving.org.

LEGACY SOCIETY MEMBERS

Jeffrey Sutton
Jeffrey Welch

THANK YOU

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The following companies and their representatives or individuals have pledged a minimum of $50,000 for the operations, educational outreach, research and initiatives of The Foundation:

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Peter Spellar
Will Stoecker**

*New donor in 2016–2017
**Deceased

We have made every effort to ensure the accuracy of the data. If you feel there has been an error, kindly contact us so that we can make the correction. Thank you!

WILLIAM E. KAHLERT MEMORIAL GOLF TOURNAMENT

Many thanks to Dennis Anderholm and his leadership and outstanding efforts to organize and produce the very successful 2nd Annual William E. Kahlert Memorial Golf Tournament in San Antonio, Texas, in March 2017.

The Tournament grossed more than $80,000 and had 77 players! Thank you to everyone who volunteered, played and encouraged your companies to sponsor.

The EVAPCO team won the trophy for 2017, and Greg Kahlert admits divine intervention on his last putt!

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The Foundation is a 501(c)(3) education and research organized representing more than 10 years of support to the advancement of natural refrigeration. All donations are fully tax deductible.

Back to Basics: To Reduce the Energy Burden, Reduce the Load

New technologies have led to improvements in energy efficiency, but it will take a new and smarter approach to industrial refrigeration system design to harness the full potential of energy savings – systems that are environmentally sound and cost-effective.

"The rules of thumb that engineers still go by, because that's how they were trained, may have been accurate in the 1950s, '60s and '70s, but those systems were not like the enormous, process critical ones we have today," said Steve Jackson, president of PermaCold Engineering Inc.

Taking a more forward-thinking approach means that refrigeration systems can be designed more efficiently. And that can mean something as simple as renewing a focus on load.

First, by stopping heat from entering a facility in the first place through lighting, doors, walls and variable frequency drives on evaporator fan motors. And second, by optimizing the system for its purpose-built application, a.k.a. design conditions, component sizes and computerized control systems.

More load means greater costs, more chemicals, more time spent on maintenance, more sewage and higher electric bills. Being clever in managing refrigeration load can produce greater energy efficiency without sacrificing reliability, Jackson said.

Not only are evaporators, compressors and condensers oversized, but so are pipes, valves, support systems and anchorage systems. "Contractors should not just look at condensers [when designing for efficiency], but at compressors and evaporators that are too big, at suction piping, at the insulation package and the hangers. You've got to scale it all back," he said.

Here are Jackson's five steps toward a smarter, more efficient refrigeration system.

1. DROP HEAD PRESSURE/ TEMPERATURE

By dropping head pressure from 160 to 90 pounds-per-square-inch discharge pressure, a facility will save 25 to 30 percent on energy, mainly due to the lower horsepower needed to run the compressors. "We did this at a plant in North Dakota where they were running 150 to 160 psi discharge pressure year-round because that's the way it had always been done," Jackson says. "We had to upsize some piping because they had pre-existing issues with high pressure liquid and hot gas feeds, but they now maintain 90 psi head pressure for much of the year."

For years, engineers have designed for a 150 to 180 psi head pressure (85-95 degrees), regardless of wet-bulb temperature and winter operating conditions. With current technology, given the correct ambient conditions, a 130- to 140-psi design condensing pressure can be achieved in most locations.

Additionally, one should ask why water is running through the condenser if ambient conditions allow for dry operation. An engineer must look at the ambient conditions and operating characteristics of a plant to intelligently design a condensing system to match. A hybrid system is often the best solution, allowing for both lowering head pressure and saving water, sewer, chemicals and energy.

> More load means greater costs, more chemicals, more time spent on maintenance, more sewage and higher electric bills. Being clever in managing refrigeration load can produce greater energy efficiency without sacrificing reliability.
>
> **–Steve Jackson, president of PermaCold Engineering Inc.**

2. RAISE SUCTION PRESSURE/ TEMPERATURE

Depending on the engineer, refrigeration systems are commonly designed using evaporators with a 10- to 15-degree temperature differential (TD). By using larger and more efficient evaporators, that TD can be dropped, which will result in significant compressor efficiency gains, leading to increased savings.

Simple engineering decisions, such as placing VFD's on evaporator fans, can have a ripple effect throughout the refrigeration system because they not only reduce the energy consumed by the fan but also the heat released by the fan into the space that then must be removed. These ripple effects, along with simply removing load from the space by switching from fluorescent to LED lighting, must be considered when designing a modern refrigeration system.

3. PROPER COMPUTER CONTROL SYSTEM

A well-designed computer control system will allow suction pressure to rise and discharge pressure to fall when conditions are satisfied. In addition to this, it will control VFDs on evaporator fans, condenser fans and compressors to work together to maintain the highest efficiency level for the system as a whole.

"With an old system, you can walk into an engine room and see four compressors running, two at 100 percent and two at 50 percent, because the control system isn't smart enough to shut any of the compressors off," Jackson said. "If you don't have a load, compressors should be staged to turn off."

4. THE LED SOLUTION

Modern LED lights are vastly superior to those used even five years ago and can result in as much as 35 percent reduction in refrigeration load. Interior lights used in older facilities, such as halogen, high-pressure sodium and metal halides, generate a tremendous amount of heat, thus consuming energy. LED lighting systems emit heat at a 90 percent slower rate than conventional lighting systems, while using half the power.

They also instantly illuminate, which means they only need to be lit when the facility is in use. "Whether they are turned on by motion sensors, timers or manually, the LEDs operate only when the facility is in use to further reduce the heat output and the amount of horsepower needed in the refrigeration system engine room," Jackson said.

Finally, LEDs last thousands of hours longer, and are water resistant and shatter resistant, reducing replacement costs and maintenance.

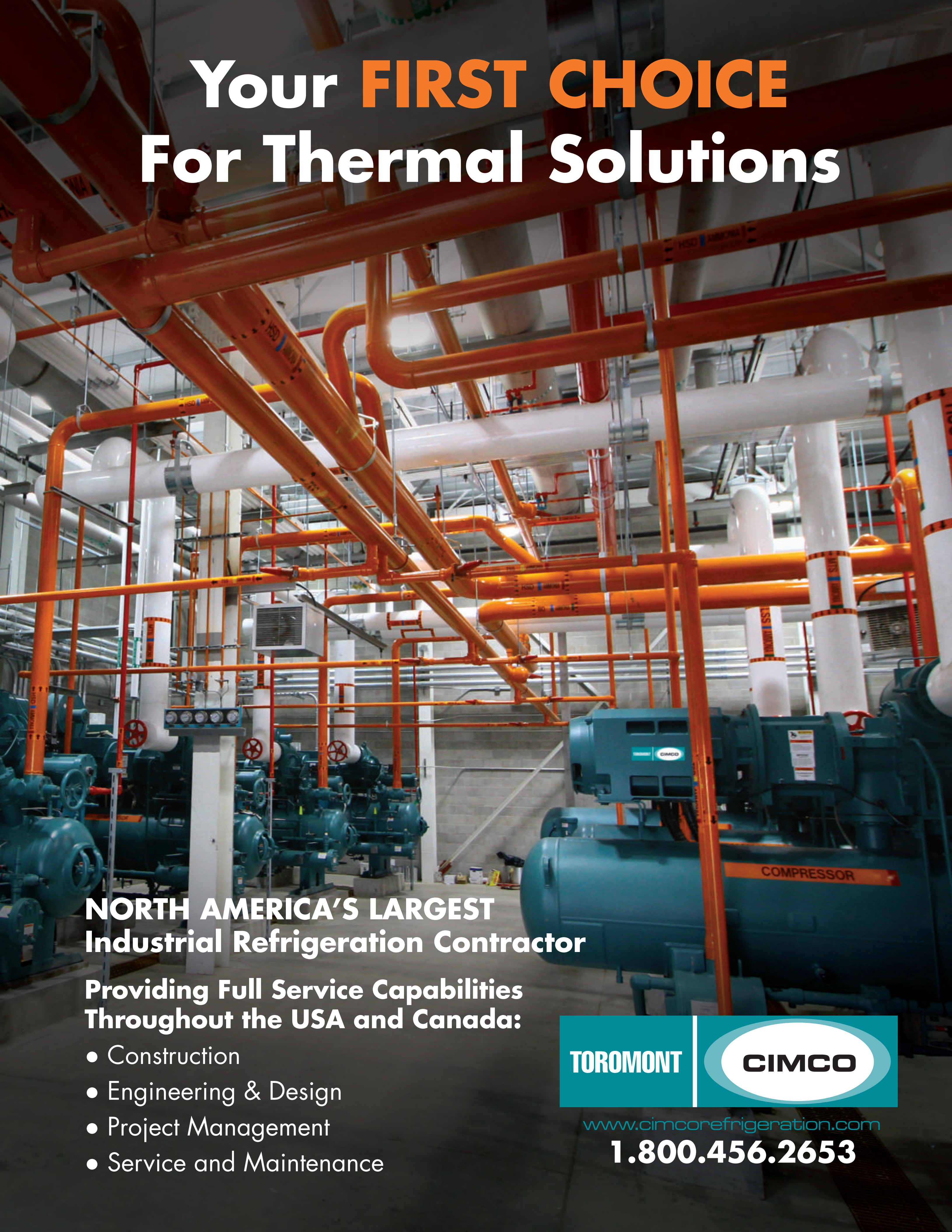
5. BETTER DESIGN OF DOORS

More efficiently designed doors can reduce the load significantly. Quick-opening doors, tied to motion sensors so they automatically open and close, minimize external heat coming into the system, along with cooled air leaving the system.

In the final analysis, the "Rule of Thumb Engineering" is no longer valid for modern freezing and storage processes in a modern refrigeration system. Instead, one should consider how to prevent heat from entering the system in the first place, and how to design the system so it is inherently more efficient.

Simple engineering decisions, such as placing VFD's on evaporator fans, can have a ripple effect throughout the refrigeration system because they not only reduce the energy consumed by the fan but also the heat released by the fan into the space that then must be removed. These ripple effects, along with simply removing load from the space by switching from fluorescent to LED lighting, must be considered when designing a modern refrigeration system.

Ambient conditions for the year must also be considered during the design to avoid missing the ability to run dry, run at lower head pressure, or both. This may sound like an expensive approach, but, it is by far the more economical approach when life-cycle costs are considered, as it gives you optimal savings during operation.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Situational Awareness Does Matter

I have often thought about situational awareness, but only on a cursory level. In my experience in dealing with emergencies, and seeing how people act in some situations most people seem oblivious to what is happening or can happen. Here is a recent experience I had that jarred me again into thinking about situational awareness.

I was returning from hiking one morning and as I rounded a curve I noticed four birds in my lane. I was going about 55 mph, and my first thought was these birds will fly out of the way. I didn't slow down. In the couple of seconds that it took me to get up close to the birds I suddenly realized these four birds were baby ducklings, and they couldn't fly. At the last second I swerved to avoid them. If I missed the last one in the line, he was a very lucky duck.

Are we like those ducklings? They were completely ignorant of the danger they were in. We may have some idea of what is happening in a situation, but our perception of what is happening may be incorrect. Situational awareness does matter and can make the difference between a good outcome and a very poor one.

Several weeks ago I took the opportunity to spend a Saturday attending two free presentations put on by a State Emergency group. One of the presentations was titled "Flawed Situational Awareness." That piqued my interest and I was well rewarded by attending. The presenter was Dr. Richard Gasaway, who before getting his PhD, served more than 30 years as a firefighter, EMT-paramedic, lieutenant, captain, training officer, assistant chief and fire chief. Besides being very experienced, he made the presentation very interesting.

Dr. Gasaway mentioned that there are many barriers to our situational awareness. So far he has identified 116. Some of the common ones are:

Urgency: The faster conditions are changing the more urgency we feel. We take short cuts, and short cut best practices. We jump right into solving the problem, and act without much thought instead of trying to understand the problem.

Over Confidence: We get over confident by doing things that fall short of best practice, and getting away with it. Our past experience can lead to over confidence, and was that past experience based on best practice or just luck?

Complacency: You let your guard down, and are not paying attention. In hazardous situations, over time, you can become complacent in future incidents because of your past successful experiences. You no longer have fear, or even concern.

Multi-tasking: Doing many things badly, and thinking we are doing them well. Dr. Gasaway stressed that it has been proven time and again that the human brain cannot multi-task. The brain "time shares", and the more difficult a task or the more mental effort required for a task the more that task dominates your thoughts and actions. A person needs to prioritize and delegate to avoid multi-tasking failure. There is a good reason for "span of control." Are you out of control with too many tasks to handle at the same time?

Short term memory overload: You can hold about 7 pieces of information in your short term memory. The pieces of information that you can hold reduces under stress. Writing things down, or using checklist/worksheets can be very helpful.

Auditory Exclusion: You tune out information coming in, and the brain stops listening. Whatever the message is, it never gets processed. For example, the longer someone talks on a radio the less information is actually passed.

Task Fixation: Not paying attention to the bigger picture. For example, when doing hand-eye actions you can be focused on a task while at the same time you hear information coming over the radio. Even though you hear it, you don't understand it because your brain doesn't process it due to fixation on the task.

Another interesting point Dr. Gasaway talked about had to do with practice. Everyone has practiced something, whether it's the piano, driving a car, golf, or preparing for an emergency. I have thought about "practice" a fair amount and have wondered if I am getting what I want out of the practice I'm doing.

What do we do when we are trying to learn something? We practice. I would guess that most of us has heard the statement "Practice makes perfect." That's not actually true. Practice only makes perfect if we are doing whatever we are practicing, perfectly. What practice really does is make permanent. So here's a lesson we should learn: Are we practicing properly to achieve the end result we're looking for?

For example, a few months ago I was involved in an emergency exercise where all those participating were reviewing and "practicing" their ammonia response. This particular company has an outstanding group of dedicated and trained individuals. They had set up their incident command structure with an Incident Commander, a Scribe, Operations Chief, Logistics Chief, Safety Officer, Medical Team, Medical Transport, Entry and Backup teams, Decontamination Team, Environmental Monitors, etc. Also, the responding Fire Department units participating in the drill worked closely with the company teams during the entire exercise. This was a great training exercise, and all involved were learning and practicing to deal with future ammonia emergencies.

During the debriefing, after the exercise, each position had the opportunity to state how they thought things went. All this was done in an atmosphere of

"How can we improve?" with no judgement on responses. My turn came and I said "You guys are awesome! There are very few companies that do this type of training, involving as many people as you do. However, in doing this training it is important to practice correctly, so when a future incident happens you don't have to think much, but your practice has your actions permanently in your memory."

To illustrate my point I briefly related a comment from some of the survivors of the World Trade Center event in September 11, 2001. One particular company in the World Trade Center had practiced for several years on how to efficiently and correctly evacuate down the stairways out of the tower. Some of those survivors commented "I didn't realize I wouldn't be able to think." The years of practice had paid off and they didn't have to think in that emergency situation about what they needed to do, they just did it.

I asked the group, "Was this ammonia drill practice as close as possible to what you would do and might happen in a real ammonia emergency? Remember that the practice you do makes your actions permanent. In this particular exercise the entry and backup teams wore Level B suits (partially encapsulating), which should have had tape applied at the ankles, wrists, and around the face mask. The taping was skipped. So what are you learning? You're learning to skip this step."

Another example, while wearing a Level A total encapsulated vapor tight suit you should not kneel directly on the ground or surface unless some type of protective material is used to kneel on. This reduces the possibility of puncturing or tearing the suit, which is your protection from the potentially harmful environment. During several drills, I have seen more than one of the entry team members kneel directly on the ground to get into a position to accomplish a task (recall Task Fixation listed above).

In one case, just a few months ago, one of the entry team members kneeled in a pool of a very high concentration of ammonia and water. Even though these were drills, just being in a Level A suit, in a situation where it is challenging to see and/or hear people, people get focused on their specific task. Situational awareness matters. The practice/training ended up skipping the step of protecting the suit, which was not the permanent action that should be repeated.

How can we have better situational awareness? It takes practice. Make your practice/training as close to correct as possible so when an incident occurs some of the actions you perform can be done with little thought, while your brain can concentrate on more important information as well as the big picture.

Attention: End Users and Contractors working in Illinois

In May of 2015, IIAR was notified that inspectors with the Illinois State Fire Marshal were requesting that ammonia vessels as part of refrigeration systems be internally inspected. Representatives from the IIAR met with the Division Chief and several members of the Illinois Board of Boiler Rules in June of 2015 and presented the case that internal inspections for vessels in ammonia refrigeration systems need not be internally inspected for a number of legitimate reasons, the foremost being that internal corrosion has never been observed in ammonia refrigeration systems.

Subsequent to this meeting, the Division Chief agreed to write an inspection procedure for ammonia refrigeration vessels and submit it to the board for approval. Unfortunately, he was not able to accomplish this before his retirement.

When it became apparent that the proposed procedure had not been approved, the new Division Chief was contacted and briefed on the situation. After a period of consideration, the Division Chief informed the IIAR that inspectors will not be required to request internal inspections for ammonia refrigeration vessels, but that the proposed procedure for inspecting ammonia refrigeration vessels would not be considered. The result is that inspectors from the agency can still request internal inspections if they desire, although it is not likely.

Rather than insist on a formal special inspection procedure for ammonia refrigeration vessels or a public statement of intent, IIAR decided that a better approach would be to address the source for Illinois' general inspection requirements, which is the National Board Inspection Code. IIAR will examine the current inspection rules and determine if special exceptions are warranted for ammonia refrigeration vessels. In the likely case that engineering analysis supports changes, these will be submitted to the NBIC for consideration. This effort is in its early stages and will probably take many months.

In the meantime, we request end-users and contractors working in Illinois to alert IIAR to any requests or demands for internal inspections of ammonia refrigeration vessels. We will offer assistance in challenging the request and consider re-approaching the Illinois State Fire Marshal's office if the notices become prolific.

Wealth Planning: Where to Begin on Education Funding

The IIAR and ARF reserve investment funds are currently managed by Stifel Financial Services under the investment policy established by their respective board of directors. In this and subsequent issues of the Condenser, you'll find a "financial tech tips" article from the firm on this page. Members of IIAR may use the financial services of Stifel for personal and business investments and take advantage of the reduced rate structure offered with IIAR membership.

Are you considering funding some, if not all, of your child's or grandchild's future education costs and unsure where to start? With the stress of funding your retirement, planning to fund future education costs can easily be pushed off and forgotten about. However, incorporating these costs in your monthly or yearly budget does not have to be as overwhelming as it may seem.

As the cost of education continues to rise, there's no greater time than the present to start planning for these future costs.

When it comes to saving, there's no better time to begin than the present. Treating your contributions as a monthly expense will make it easier for budgeting purposes. The first step to saving for these rising education costs is to open an account. There are several types of accounts that can be used to pay for education, including 529 plans, UTMA/UGMA (Uniform Transfers to Minors Act)/UGMA (Uniform Gifts to Minors Act) accounts, and Coverdell Education Savings Accounts (ESAs).

529 plans, also known as college saving plans, can be used for qualified expenses. There are no income restrictions for contributing to a 529 plan, qualified withdrawals are free from federal taxes, and the account owner has complete control, including the ability to transfer the account to another related beneficiary at any time. There are no age limits on when funds from a 529 plan have to be withdrawn. If all of the funds are not used on the designated beneficiary, they can continue to trickle down to related beneficiaries for other future college costs.

Investors should consider carefully the investment objectives, risks, and charges and expenses associated with a 529 College Savings Plan before investing or sending money. The official program offering statement, which includes information on municipal fund securities, is available from your Financial Advisor and should be read carefully before investing. The value of a 529 College Savings account may fluctuate, and there is no guarantee that any investment portfolio will achieve the stated goal. Your investment may be worth more or less than its original value.

UTMA accounts are custodial accounts that are to be used for the benefit of the minor. Earnings are subject to income or capital gains tax. Funds from an UTMA/UGMA account are more flexible, as they do not have to be used for education. The custodian on the account can use these funds to pay for expenses for the child; however, upon reaching legal age, the child will take ownership of the funds and can use them for any purpose.

An ESA can be used for not only college expenses but also for elementary and high school expenses. Contributions into the ESA grow tax-deferred until withdrawn. There are some limitations, however. Contributions are capped at $2,000 annually and are not tax deductible. You are restricted from contributing to a Coverdell ESA if your modified adjusted gross income is more than $110,000 (as a single filer) or $220,000 (for a joint filer). Also, the assets from an ESA must be used before the beneficiary turns 30 years of age.

Regardless of which investment vehicle, or combination of vehicles, you choose, consistent saving is crucial. Whether you have less than a year or more than a decade to plan for these future costs, even a small amount of saving each month can go a long way in helping fund your child's or grandchild's education. As the cost of education continues to rise, there's no greater time than the present to start planning for these future costs.

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For additional Wealth Planning assistance contact your Stifel representative: Jeff Howard or Jim Lenaghan at (251) 340-5044.

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To Stay Competitive, "Do the Math and Trust the Science"

RECOMMENDED PRACTICES

Reduced-charge central ammonia refrigeration systems do not have to mean lower efficiency. With current technology, industrial refrigeration systems can be designed with a smaller ammonia charge and still operate at high efficiency. The key is trusting the math when designing a system.

"My analogy is that you don't use the same computer that you did in 1988," said Peter Lepschat, corporate manager of engineering services at Henningsen Cold Storage, Co., where he works on the design and construction of new facilities. "It's the same thing with refrigeration. Control and design technology have advanced to the point where there are many things you can do now that you couldn't just a few years ago. From a contractor's perspective, customers like us are going to demand that you learn this new technology. If you don't, at some point you will go out of business."

An example of advanced technology is the evolution of the DX coil. "Previously, DX coils for freezers did not work well," Lepschat said. "The coil designers didn't have a [good idea of] how to design a coil with the right tube sizes and circuiting for DX use." The expansion valves did not provide reliable operation. "But with advanced modeling software that now can be used, [along with new valve and control technology] you can scientifically design a coil that will work in direct expansion mode."

DX coils are a great way to reduce charge, eliminating the low-pressure receiver, pumps and larger liquid ammonia piping used with overfeed evaporators.

When designing a system, Lepschat also recommends rejecting traditional rules of thumb. "The industry rule has always been that you need one ton of refrigeration capacity for every 400 square feet of freezer" he said. "That was probably true in 1955 when walls were insulated with sawdust or cork, you had slow-operating doors and highly inefficient lighting. But people still use that number. The result is a system that is way oversized. It's all wasted ammonia. Do the math and trust the science to figure out what you really need."

Lepschat recommends hiring an engineering consultant who is not financially invested in the facility to help with the design. "There is no incentive for contractors to lower [the system] charge," he said. "They figure that if something has always worked, why mess with it? You need an engineer who is willing to 'right-size' components and is not going to put in additional margins that are not needed. Designing systems to be the right size has no effect on efficiency. It just removes ammonia from that system that is serving no useful purpose."

One simple approach Lepschat takes is to consider liquid refrigerant as the enemy. Managing the liquid level in an ammonia vessel used to be more difficult, due to the use of fixed-float switches. But with the advent of electronic level probes that monitor liquid levels, and control systems allowing easy level adjustment, the levels in vessels can be fine-tuned to the minimum safe and stable operating level, typically allowing for a reduction in ammonia charge. "You might be able to get rid of a couple of tons of ammonia that was just taking up space in your vessels," he said.

Another area that can provide opportunity for sizable reductions in ammonia charge is the liquid piping of a system. It is very important to size piping properly. Many systems have grossly upsized liquid lines. It is not unusual for a designer to install three-inch liquid pipes when two-inch pipes would be sufficient. "There is an old saying in the industry that pipe is cheap. If you've done the math and a two-inch pipe works from an engineering standpoint, use the science and size it right," Lepschat said.

Another methodology Lepschat uses is to put yourself inside the system when designing it. "For example, if you have a low-pressure receiver, consider its purpose," he said. "It contains liquid in the bottom, and there's a pump sending it to the evaporators. The ammonia then comes back as a gas/liquid mixture. It separates and returns the gas to the compressor, and the liquid goes back to the pump. So, you've got all this liquid ammonia, but what is it doing? Well, the liquid is feeding the pump and the vessel is maintained to keep the pumping liquid going to the freezer evaporators. Ask yourself, how can I get the same effect with less ammonia?"

One way is to minimize the liquid inventory by holding the operating liquid level at or near the bottom of the vessel, so that the much smaller-diameter drop leg contains all the ammonia feeding the pump. This may require extending the drop leg to make sure you maintain NPSH requirements at the pump inlet, but the charge reduction would be significant.

"These are only a couple of examples of low-hanging fruit that we have found," Lepschat said. "In reality, every component of your system offers some opportunity to reduce charge. You just need to take the time and ask the questions."

In the final analysis, low-charge systems eliminate wasted ammonia, while maintaining efficiency. "The technology is there, and that's where the industry is headed. Everyone needs to get on the train," Lepschat said.

Closing the Flammability Gap

The safety of synthetic refrigerants versus anhydrous ammonia continues to provide a major point of debate within the refrigeration industry. Since ratification of the Montreal Protocol two decades ago, there has been a trend toward eliminating non-flammable synthetic refrigerants that have ozone depleting potential or global warming potential.

> "Codes and standards have shied away from allowing flammable or toxic refrigerants in human comfort, which is air conditioning, and commercial applications where there is a risk of occupants being exposed to refrigerant in the event of a leak, but that's changing."
>
> **–Jeff Shapiro, IIAR code consultant.**

At the same time, questions concerning the flammability and toxicity of replacement refrigerants have remained at the forefront.

From a performance perspective, ammonia has always been recognized as an exceptional refrigerant, but flammability and toxicity concerns have historically driven some refrigeration applications towards non-flammable, non-toxic synthetics. However, the flammability gap has been closing rapidly because new synthetic blends that are coming to market with low-ODP and low-GWP characteristics are flammable on a par with ammonia.

New synthetic blends and ammonia fall into a class of refrigerants called "2L." The class, established by ASHRAE Standard 34, applies to flammable refrigerants that are not easily ignited and will burn with a relatively low flame velocity if they are ignited. ASHRAE 34 further divides 2L refrigerants into two subcategories – A2L and B2L -- based on toxicity, with A2L being the lower of the two.

"Codes and standards have shied away from allowing flammable or toxic refrigerants in human comfort, which is air conditioning, and commercial applications where there is a risk of occupants being exposed to refrigerant in the event of a leak, but that's changing," said Jeff Shapiro, IIAR code consultant. "Now that there are synthetic refrigerants in the 2L category, there's been growing interest in mitigating the risk of low-flammability refrigerants, as opposed to outright prohibiting them."

Changes being proposed so far to model codes and standards to permit 2L refrigerants have been divided into two areas. As mentioned above, one is human comfort, or air conditioning, applications. Some codes and standards will likely permit the use of A2L refrigerants for this purpose, but refrigerant quantities will be limited and engineered safety controls, such as leak detection and ventilation, will be provided to reduce risk. Likewise, A2L refrigerants will be recognized for commercial applications where a larger refrigerant charge is kept in a refrigeration machinery room or outdoors, with a non-flammable, non-toxic secondary refrigerant serving occupied spaces.

Less certain is what codes and standards will, or won't, allow with respect to any systems that circulate liquid A2L refrigerant in occupied spaces. Detection and mitigation features needed to deal with leakage events in occupied spaces become much more complicated with field-assembled equipment located in occupied building areas.

Beyond direct ignition of a refrigerant leak, a secondary concern that should not be overlooked is toxicity. "Ammonia shares the characteristic with A2L refrigerants of being mildly flammable, but that is pretty much where the parallel ends," Shapiro says.

ASHRAE 34 classifies ammonia as a Group B refrigerant based on toxicity of the chemical itself. However, ammonia is relatively clean burning fuel when it catches fire. In contrast, leaked synthetic refrigerants in pure form are less toxic than ammonia, but the consequences of decomposition due to heat or flame exposure are far worse than ammonia. If an A2L refrigerant is burned, either by ignition or by exposure to a flame, highly toxic and corrosive products of combustion may be produced, creating a life-threatening condition for any occupants who may be exposed.

Although A2L refrigerants are not as risky as pure hydrocarbon refrigerants, such as isobutane, flammability risk remains a concern that cannot be overlooked. "A recent study evaluated the ignitability of A2L refrigerants in scenarios such as a commercial kitchen, a residential hallway and rooftop units.

Leak conditions were created in the presence of ignition sources to test what would happen, and significant fires with dangerous products of combustion were observed," Shapiro said. "Given the known risks associated with synthetic A2L refrigerants, we need to get it right when it comes to requiring adequate safety measures in codes and standards."

Synthetic A2L refrigerants that are coming to market don't have an odor. Therefore, absent detection devices, a leak may not become evident until there is a flammability or toxicity issue. Most applications will require some type of leak detection device or system, and these may have to be specific to an individual gas. However, even if these safety features are initially satisfactory, long-term reliability must be addressed to ensure public safety.

"Unfortunately, we currently have no standard for any kind of system to detect synthetic A2L gases to tell us how many detectors you need, where they should be placed, what the reliability is, how they will be connected, how often they will be tested or who is going to test them," Shapiro pointed out.

In contrast, the International Institute of Ammonia Refrigeration has made a lot of progress with ammonia detection, and many new ammonia-detection requirements have been incorporated into IIAR 2 since 2014. "Ammonia is much easier to deal with from a detection perspective because you're only trying to detect a single gas with known characteristics, and even if detection fails, the odor of ammonia is self-alarming. You will smell it and you'll naturally want to move away, even at low concentrations that are below established safe-exposure thresholds," Shapiro said.

With ammonia having similar flammability to synthetic A2L refrigerants that are likely to become commonplace in air conditioning and other refrigeration equipment, the only barrier to broader acceptance of ammonia in such applications is the question of toxicity. And given ammonia's advantage of being self-alarming at non-hazardous concentration levels, versus odorless synthetics that must rely on detection equipment to identify a leak, ammonia is certainly positioned for increased consideration as a replacement for outgoing ODP and GWP refrigerants.

"Ammonia is much easier to deal with from a detection perspective because you're only trying to detect a single gas with known characteristics, and even if detection fails, the odor of ammonia is self-alarming.

–Jeff Shapiro, IIAR code consultant.

Court Rules Against EPA Regulating HFCs through SNAP Program

iiar government RELATIONS

BY LOWELL RANDEL, IIAR GOVERNMENT RELATIONS DIRECTOR

On August 8, 2017, the United States Court of Appeals for the District of Columbia Circuit issued a ruling in the case of Mexichem Fluor Inc. vs. the EPA finding that the Environmental Protection Agency (EPA) exceeded its statutory authority by promulgating a rule in 2015 that regulated the use of hydrofluorocarbons (HFCs). The 2015 regulation was issued by EPA through its Significant New Alternatives Program (SNAP) as a part of the Obama Administration's plan to reduce greenhouse gas emissions. The regulation restricted the use of 38 HFCs in over 20 uses including retail food refrigeration.

In response to the regulation, two HFC manufacturers sued EPA challenging the validity of the rule. The companies argued that EPA exceeded its statutory authority under Section 612 of the Clean Air Act by requiring manufacturers to replace HFCs. They also argued that the removal of HFCs from the approved substitutes list was arbitrary and capricious.

Given the change in administrations, there was initially some uncertainty about how the new Trump Administration would approach the legal challenge to an Obama era regulation. The Trump Administration has already taken numerous actions to dismantle regulations finalized under President Obama. This includes declining to defend legal challenges to Obama regulations and proactively moving to reverse Obama era actions. However, in this case, the Trump Administration chose to defend the EPA regulation during the court proceeding.

The lawsuit centers around Section 612 of the Clean Air Act, which authorizes EPA to replace ozone-depleting substances with chemicals, product substitutes, or alternative manufacturing processes that reduce overall risks to human health and the environment. EPA administers Section 612 through the SNAP program through which the agency maintains a list of approved and prohibited substitutes.

The rule issued in 2015 changed the designation of some HFCs, including R404A, R134a, R407C and R410A, from the approved list to the prohibited list. The policy change impacted manufacturers that had replaced the ozone depleting refrigerant R-22 with a refrigerant such as R404A or R134a (when it was on the approved list) by prohibiting its future use in certain applications.

This drove the two companies to challenge whether EPA had the authority to require a manufacturer to now replace HFCs, which are non-ozone-depleting substances, with another substitute. In addressing the question, the court cited EPA's historical stance that it did not possess authority under Section 612 to require the replacement of non-ozone-depleting substances. The court cited EPA statements from 1994 that Section 612 "does not authorize EPA to review substitutes for substances that are not themselves" ozone-depleting substances.

EPA defended the 2015 rule by arguing that Section 612 does provide sufficient authority to require the replacement of a non-ozone-depleting substitute that had previously been on the approved list. EPA argues that the word "replace" in the statute applies not only to the initial substitution for an ozone depleting substance such as R-22, but any subsequent use of a substitute. In effect, EPA asserts that replacement is not a one-time occurrence, but rather an ongoing action.

The court rejected EPAs rationale stating that under EPA's current interpretation of the word "replace," manufacturers would continue to "replace" an ozone-depleting substance with a substitute even 100 years or more from now. The court went on to say that such a boundless interpretation of EPA's authority under Section 612 borders on the absurd. EPA's authority to regulate ozone-depleting substances under Section 612 does not give EPA authority to order the replacement of substances that are not ozone depleting but that contribute to climate change.

While the court was clear that Section 612 of the Clean Air Act does not authorize EPA to regulate HFCs, it offers the agency some options for addressing the use of HFCs. The court cites the Toxic Substances Control Act (TSCA), National Ambient Air Quality Standards Program and the Hazardous Air Pollutants program as alternative authorities that EPA could consider using to restrict

The court went on to say that such a boundless interpretation of EPA's authority under Section 612 borders on the absurd.

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HFC use. The court makes clear that its ruling does not affect these authorities in any way.

The court also addressed the theory that EPA could potentially take retroactive action to disapprove of a substitute for an ozone depleting substance. Under a retroactive disapproval approach, EPA could potentially prohibit manufacturers from making products that use HFCs even though those HFCs were approved as substitutes when a manufacturer decided to initially replace an ozone-depleting substance with HFCs.

In order for EPA to advance the retroactive disapproval approach, the court lays out three steps the agency must take:

EPA would have to reasonably conclude either (i) that Section 612(c) provides EPA with statutory authority to employ a "retroactive disapproval" approach or (ii) that EPA has inherent authority to retroactively disapprove a prior replacement, even a replacement that occurred many years ago.

EPA must explain the basis for its conclusion and explain its change in interpretation of Section 612(c).

EPA must comply with applicable due process constraints on retroactive decision-making. To satisfy the Due Process Clause, EPA must at a minimum provide regulated parties fair warning of the conduct a regulation prohibits or requires. In this case, for example, even if EPA has statutory authority to retroactively disapprove the replacement of an ozone-depleting substance with HFCs, EPA plainly may not impose civil or criminal penalties on a manufacturer based on the manufacturer's past use of HFCs at the time when EPA said it was lawful to use HFCs.

It is not clear what EPA's next step will be. After the court's ruling, an EPA spokesperson indicated that the agency will be considering its options. EPA could choose to appeal the court's decision to the Supreme Court. The agency could also exercise one of the options suggested by the court such as claiming the authority for retroactive disapproval or utilizing one of its other statutory authorities like the Toxic Substances Control Act to regulate the use of HFCs. Alternatively, EPA could take no further action, let the court ruling stand, and not continue to actively pursue the regulation of HFCs.

Industry also has the option to consider appealing the court's decision. While Mexichem and Arkema Inc. opposed the EPA rule and brought the court case, other companies supported the rule and had made significant investments in new refrigerants. For example, Chemours expressed disappointment in the ruling and stated that it is assessing its options, including an appeal. Honeywell, another company that has made investments in alternatives to HFCs, urged EPA to continue its efforts to phase out HFCs despite the court decision.

The outcome of the lawsuit creates additional uncertainty regarding how the U.S. government will address the future use of HFCs. President Trump and several of his key policy advisors continue to express skepticism on climate change and climate policies. The United States has officially withdrawn from the Paris Climate Agreement, but no official policy has been articulated on the Kigali Agreement, which expands the reach of the Montreal Protocol to include a global phasedown of HFCs.

Given that the court has ruled that the SNAP program does not give EPA the authority to regulate HFCs, the agency would need to find an alternative mechanism to effectuate the phasedown of HFCs called for under Kigali. While Trump's EPA and Department of Justice defended addressing HFCs through SNAP, it remains unclear how aggressively EPA will either appeal the court's decision or find another avenue to pursue restricting HFCs in the future.

Despite these policy uncertainties in the United States, the overall momentum of industry remains in the direction of moving away from HFCs. Over the long term, global policies are expected to continue supporting the Kigali Agreement and HFC phasedowns. And, whether driven by U.S. federal policies, or industry trends, HFC use in the United States is expected to decline as well. These trends continue to represent an opportunity for growth in the use of natural refrigerants.

EPA must comply with applicable due process constraints on retroactive decision-making. To satisfy the Due Process Clause, EPA must at a minimum provide regulated parties fair warning of the conduct a regulation prohibits or requires.

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